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It may be useful to start with a brief description, from PJM's point of view, of economic dispatch. We consider it the lifeblood of any transmission operator, whether a vertically integrated utility or an RTO like PJM. Security constrained economic dispatch involves the use of a mathematical formula, an algorithm, to match up the lowest-cost resources needed to reliably serve the load every hour of the day, 365 days of the year. Traditional utilities handle this responsibility by using a cost-based approach, taking into account fuel expenses and other factors. PJM and other ISO/RTOs employ a bid-based methodology over a regional footprint as part of a robust wholesale power market.

The key to success is to bring as many resources to the table as possible — so the math can solve the equation. Through economies of scale, PJM can use new technology and methods to analyze and incorporate the benefits of diversity on both the generation side and the load side to further drive down costs.

The history of economic dispatch is really PJM's history and goes back to our formation in 1927, when three utilities signed the PA-NJ Agreement based on an estimated savings of \$45 million for the decade ending in 1935. PJM has come a long way since then, but the fundamental principle behind the way PJM manages the flow of electricity is the same. *Our purpose is to maintain reliability and efficiently manage load to achieve the highest value for our customers.*

For 78 years, PJM has worked toward those ends so that today the benefits of economic dispatch are delivered by an operation, including more than 1,000 generators, that serves 51 million people in 13 states and the District of Columbia. At the end of my testimony, I cite some reports that measure our progress, the most recent of which includes a study by the ISO/RTO Council (IRC), outlining benefits and cost savings from our collective operations.

But first let me outline why I say economic dispatch and the evolution of PJM are so closely aligned. When PJM operated as a power pool, the idea was to reduce the amount of installed capacity, as compared to the total amount required by separate utilities, while maximizing the benefits of load and generation diversity. With the addition of two more utilities to the pool in 1956, the meaning of a power pool changed with the use of an accounting formula to forecast demand and plan resources accordingly.

Under the 1956 PJM Agreement, each of the five utilities agreed to meet forecasted capacity requirements by installing or arranging for sufficient capacity and related transmission facilities to uphold its end of the forecast requirement. The utilities could either meet their obligations with their own resources or by purchasing capacity, the forerunner of the modern wholesale electricity market.

As a distinct entity, PJM matured by keeping pace with technology and adding new services for its members. The PJM Agreement established an operating capacity requirement and a daily operating reserve requirement, a critical component in maintaining system reliability. In the mid-1960s, PJM started using computer programs to determine those reserve requirements. By 1973, the PJM pool was capable both from an organizational standpoint, through the Office of Interconnection, and from a technological standpoint to centrally dispatch generation within the power pool. The PJM pool then became a single system using economic dispatch within the constraints of reliability and fuel availability.

I wanted to spend some time on the early history because it illustrates a successful track record of economic dispatch as developed by the utilities in the PJM area. It's important to point out that utilities have long recognized the value of pooling resources without the impetus of regulation. In fact, a 1990 study by McKinsey and Company showed that PJM provided over \$1 billion annually in value to members. Without this evolution and demonstrated value, we would not be discussing SCED here today.

PJM and its members continued through the 1970s and 80s to improve system operations and generation usage, operating under a pool-wide transmission tariff and a cost-based energy market within one control area. With the creation of PJM as a fully functioning ISO in 1996 and introduction of markets the following year, the organization moved to bid-based pricing and locational marginal pricing (LMP) to increase price transparency and better identify the lowest cost product.

While a centrally managed system requires a single operator to manage and direct every activity on the grid, a competitive market uses clear, transparent, commonly available information about grid conditions to communicate simultaneously with all market participants. Through LMP, all participants can tell when congestion or supply shortages arise and define for themselves the appropriate response. Some have incorrectly associated LMP with increased congestion – rather congestion exists on every electric system, and LMP merely makes it transparent so that market participants can take actions to manage it.

To further enhance the role competitive markets play in improving SCED, PJM and other ISO/RTOs have made significant improvements in the quality and timeliness of tools to monitor and reliably manage the grid. For example, PJM's System Control and Data Acquisition systems to acquire grid condition data, State Estimators and Contingency Analysis models are the result. One application, the PJM Security Analysis, runs every minute, processing 68,000 data points every 10 seconds and evaluating almost 4,000 contingencies to re-dispatch generators to mitigate overloads.

The bids of generators are factored into the dispatch output which in turn makes generators and possible curtailment service providers more attentive to the dispatch signal as it means something to their “bottom line.” Hence, real-time reliability is improved.

Last year, PJM implemented new problem-solving software to schedule not only which electric generating units should be operating but also when the units need to be ready. This reduces the fees customers pay to ensure enough generation is available, saving in the process an estimated \$85 million annually. On the demand response side, this past year PJM enhanced its Spinning Reserve and Regulation Markets to permit demand resources to respond in addition to generation.

Using market-based SCED has led to other direct benefits as well, such as the integration of alternative sources of generation, including wind, solid waste and hydro. At the same time, generation has become more efficiently operated under the competitive market. The average generation forced outage rate has been reduced from more than 10 percent to slightly over 7 percent since 1998. Our reserve margin requirement has been reduced from 18 percent prior to market operations to 15 percent currently, while maintaining the same reliability standards.

I hope this cursory examination of the confluence of economic dispatch with PJM’s history as a power pool and finally an RTO serves to illustrate the time-tested value of this critical component to the management of the machinery that comprises the nation’s electric grid. I won’t enumerate them all at this point, but a number of studies have quantified the benefits of RTOs, adding to the ongoing dialogue on the best way to ensure the reliable and efficient flow of electricity that drives our nation’s economic engine.

- In September 2002, a report by the Center for the Advancement of Energy Markets concluded that customers within PJM realized \$3.2 billion in total savings as the result of restructuring.
- In June 2003, a study by Synapse Energy Economics Inc. reviewed the effects of the first five years of the PJM market on three long-time PJM members in the mid-Atlantic region. The conclusion showed that their costs were from 2% to 13% lower than if the wholesale market did not exist.
- A 2003 evaluation of the increased efficiency in the security-constrained unit commitment and economic dispatch resulting from the integration of Allegheny Power into the PJM market indicated an overall savings of \$99 million for an eight-month period in 2002.
- An AEP study of nominal net benefits as a result of its joining PJM revealed a nominal net benefit of \$188 million for the years 2004-2008.

- In July, a report by Global Energy Decisions found PJM's market integrations in 2004 – Commonwealth Edison, AEP and Dayton Power & Light – resulted in annual product cost savings of \$85.4 million for wholesale electricity customers in the Eastern Interconnection.
- Cambridge Energy Research Associates in October reported that \$33 billion in savings have been realized over the last seven years when compared to electricity prices that would have been paid in a regulated environment.
- PJM released this month a study it commissioned by Energy Security Analysis that highlighted \$500 million in savings for wholesale customers as the result of PJM's expansion since 2002. It joins a growing body of recent evidence from other sectors about the value of markets and economic dispatch.
- A report released on Nov. 14 by the ISO/RTO Council on the collective benefits and value regional transmission operators bring in managing the flow of electricity to two thirds of the U.S. population found that annual costs of our services to the average customer is about \$5 per year. PJM's annual cost is about \$3.50.

### **RTO Questions**

**What are the benefits and costs of SCED, compared to the previous system used for dispatch, or to other potential alternatives? What specific benefits has SCED offered? Can you quantify these benefits, and, if so, please do so.**

In 1973 the PJM power pool implemented security constrained economic dispatch as a way to ensure the continued reliability of electric power supplies throughout its then mid-Atlantic region in light of fuel supply concerns related to the first OPEC oil embargo. It provided that power supplies would be shared to maintain service, even if fuel supplies were disrupted to one or more members, and that the power would be supplied at the lowest available price, subject to the constraint of system reliability. For 25 years, PJM dispatched generation on the principle of SCED with the economics determined by the embedded, rate-based expenses of the generators. With the advent of competitive wholesale markets in 1998, PJM modified SCED to use bid-based offers rather than rate-based expenses. The principle remained the same, but now generators were under competitive pressure to offer their power at the lowest price possible and to find ways to control and reduce costs.

At the same time, PJM and its members introduced the innovation of locational pricing through the mechanism of locational marginal pricing (LMP). LMP decisively weds the economics of the marketplace to the security needs of the bulk power supply system. Under LMP, the price for wholesale power can vary among thousands of nodes on the grid based on the presence or absence of constraints.

LMP marries the financial interests of power suppliers to the reliability needs of the grid. It sends pricing signals to attract additional power supply where needed at the time and to reduce the production of power where generation is stressing the system. As the size of the PJM region grew through the integration of new areas, the benefits of bid-based SCED were expanded to those regions. The economic benefits are the result of gains created through increased market participation, which in turn drives increased wholesale competition and efficiency. PJM could not operate an efficient organized market without bid-based SCED.

Another significant benefit is the one we share with the Midwest ISO through our Joint Operating Agreement. We have worked successfully to eliminate the market seams and exchange data that supports reliability and market coordination, permitting prices to converge and creating greater transparency.

Several studies reveal quantifiable and tangible efficiencies and consumer benefit from PJM's use of SCED. Most recently, Energy Security Analysis, Inc. found annual energy market savings of more than \$500 million because of the optimization of PJM's centrally dispatched operations using SCED. ESAI noted that PJM has developed an efficient energy market, in which the "competitive struggle" is present, as proven not only by the calculated savings but also by the decline in the average on-peak heat rate from 9,000 to 7,000 BTU/kWh from 2001 to 2004, a sign of more efficient operation of generation. Furthermore, the ESAI report conservatively estimates that favorable increases in the liquidity and diversity of PJM's markets will yield aggregate savings to consumers of between \$700 million and \$1.4 billion per year.

Overall, PJM's market operations, transmission planning, grid operation and market monitoring services cost each household in the region approximately \$3.50 per year.

**What lessons did you learn in implementing SCED? In particular, were there unanticipated benefits or costs that should be kept in mind when considering changes or improvements to the current SCED?**

There is no substitute for advanced technology, information and full communications to successfully implement SCED and fully achieve all its benefits. SCED creates tremendous opportunities for innovation, continuous improvement and initiative when previously hidden information is made available to all participants. PJM's goal is to be certain that the billions of bits of data gathered by our monitoring systems is converted into information about the status of the system and power supplies. This allows market participants to align their operations and interests with system reliability needs and in the process achieve the most efficient use of generation, demand response and transmission resources. The primary advantage of organized markets is that they permit all resources to be leveraged to participate based on their economic merit and contribution to system needs without regard to ownership. Price and operation transparency also allows efficiency and effectiveness to be measured.

Economic benefits, obviously, were expected as PJM began its organized wholesale competitive markets based on SCED. However, concomitant with the economic benefits are increased reliability and the ability and opportunities for non-traditional resources, such as wind power and demand response, to participate and compete equally with traditional resources such as fossil-fueled generation.

In the area of reliability the equivalent availability factor for generators increased by seven percent between 1994 and 1998. That increase in the availability of generators is equal to adding hundreds of megawatts of “free” capacity. It paid dividends for PJM in 1999 when we experienced extraordinarily high demand twice in July, prompting severe voltage dips to dangerous levels. Again in 2000 the benefits of competitive markets and diversity of generation paid off when the load on two extremely hot days was forecast to exceed available capacity. In both cases, PJM was able to ensure reliability of the system.

These benefits, however, cannot be achieved without investment in market structure and the technology tools necessary to administer markets and operate the bulk power supply system on a region-wide basis. It requires an economy of scale. Individual utilities generally are too small to take advantage of the tools because they lack the efficient scale of a regional organization.

**How does the operation of SCED relate to the operation of the regional market? How would a market operate in your region without SCED?**

Operation of the security constrained economic dispatch model is integral to operation of a regional market, in PJM's view. Successful markets require the liquidity that comes from the confidence placed on them by participants, investors and regulators. SCED ensures the efficiency, transparency and integrity of the market that builds that confidence. By integrating physical operation of the system with the market structure, PJM ensures itself and its stakeholders of a reliable, equitable and auditable system. SCED is a tool used in markets and by grid operators around the world to serve this purpose. PJM is aware of no other alternative.

**What effect has SCED had on the reliability of the electric system in your region? Can you quantify the effect, and, if so, please do so.**

SCED adds to the real-time reliability of the PJM system. As noted previously, SCED weds market operations to reliable operations. The information transparency of competitive wholesale electric markets using SCED, as revealed through energy pricing and LMP, discloses system conditions, perhaps even before the nature of changing system conditions is clear to grid operators. It also provides immediate financial incentive to market participants to respond to price signals in a way that is consistent with system conditions.

For example, in a paper, Fernando L. Alvarado and Rajesh Rajaraman suggest that if a PJM-style SCED model had been in operation in the Midwest at the time of the August 2003 blackout, the event may not have cascaded out of control as generators would have responded to price signals that reflected the needs of and overloads on the system. Also, the diversity of generation within a large geographic footprint of sufficient scope to make SCED most effective enhances overall reliability by reducing the dependence on any one type of generation or individual generation resource.

**What effect has SCED had on the cost of electric energy in your region, after adjusting for input costs such as fuel? Can you quantify the effect, and, if so, please do so.**

Electric energy costs have been reduced. The Market Monitoring Unit (MMU) for PJM constantly reviews energy costs. The MMU's 2004 State of the Market Report found that, when increased fuel costs are accounted for, the fuel-cost-adjusted, load-weighted, average LMP was 4.2 percent lower in 2004 than in 2003 -- \$39.49 per MWh compared to \$41.23 per MWh. As previously noted, heat rates have improved, indicating a more efficient use of the fuel used to produce electricity.

**How can RTO's SCED resources be more optimally dispatched?**

Regional grid operators must constantly examine the market structure to identify and remove barriers to optimal SCED usage. For example, those barriers could involve retail, wholesale, institutional or regulatory barriers to demand response introduction and investment. There may be further opportunities to develop markets and risk management tools, such as hedging instruments to facilitate complete participation in the marketplace. In addition, RTOs must always seek to improve the information tools they provide to increase efficiency and to help participants make better informed decisions. RTOs' scale allows them to achieve tremendous financial benefits from small increases in efficiency that would be cost prohibitive for smaller, standalone operations to attempt. With PJM's size and scale, it can make worthwhile the kind of investments in software needed for greater efficiency. PJM just last year implemented new problem-solving software that better identifies which generating units to schedule and for what period. It is projected to save customers \$85 million annually.

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